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(54) Intense microfocus X-ray source

(57) An intense microfocus X-ray source comprises a chamber 60, a turbomolecular pump to evacuate the chamber 60, an anode 86 and a cathode 50 within the chamber 60, and electromagnet coils 34 to focus electrons from the cathode 50 onto a small spot on the anode 86 to produce a divergent X-ray beam 160. The pump has a shaft 90 to which the anode 86 is connected, so that operation of the pump causes rotation of the anode 86. Heat generated in the anode 86 by the incident electron beam 150 is spread over a larger area than if the anode 86 were stationary. Consequently a more intense electron beam 150 can be used, leading to a more intense X-ray beam 160, without melting the anode 86.

Fig.1.

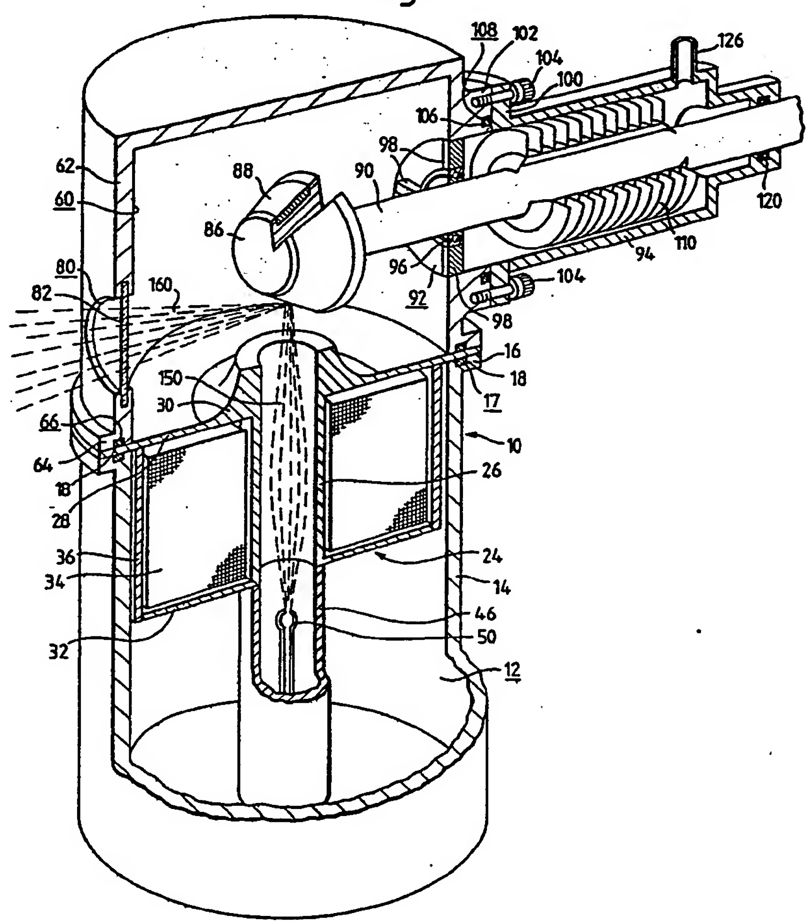

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Fig.1.

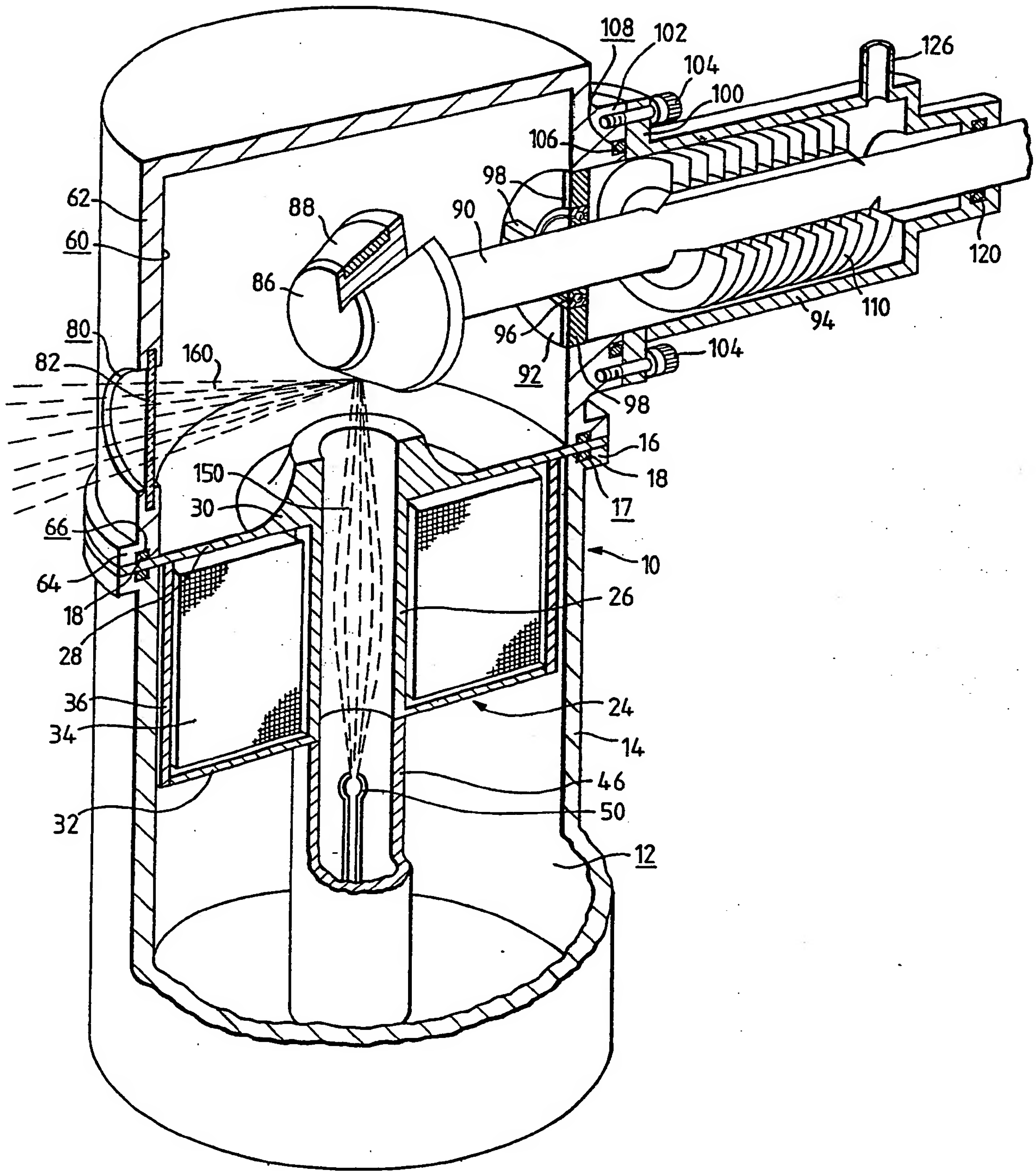
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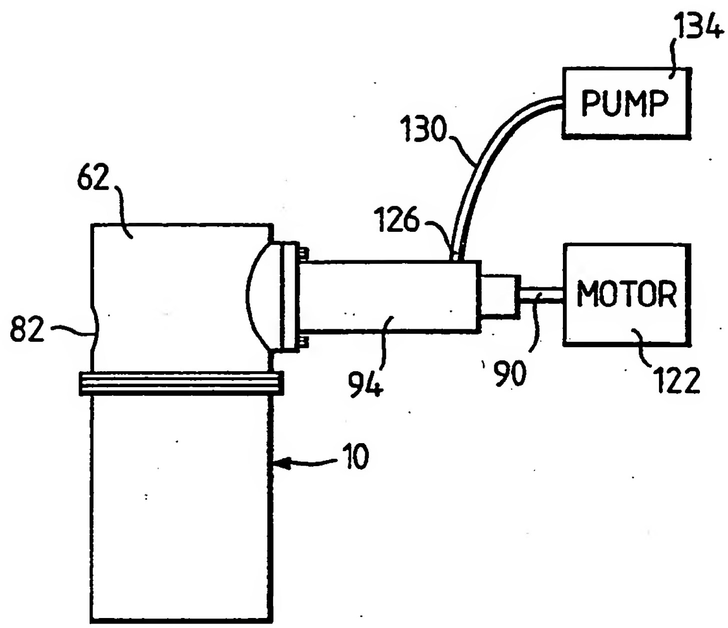
Fig.2.



SPECIFICATION

Intense microfocus X-ray source

This invention relates to microfocus X-ray sources in which X-rays are created by the collision of an electron beam with a solid target, the electron beam being focussed by magnetic or electric fields onto a small spot of diameter only a few micrometres on the target.

A microfocus X-ray source produces a divergent X-ray beam, and may be used to take magnified X-ray pictures of small objects. Such objects are placed in the beam near the source, at a distance d from the target, and an X-ray sensitive film placed further from the target, at a distance D. Because the X-rays travel in straight lines diverging from the small spot on the target, the image on the film will be magnified by a factor D/d. The definition and clarity of the image depend upon the size of the spot - the smaller the spot, the clearer will be the image. However for real-time X-ray photography, and for photography of thick or dense objects, an intense X-ray beam is required and consequently an intense electron beam must be incident on the target. In the case of a microfocus X-ray source this intense electron beam must be incident on a small spot on the target which will consequently become hot; and so the target may be damaged by overheating or melting.

In the field of non-microfocus X-ray sources, it is known that a target may be prevented from overheating by passing a cooling liquid through ducts within the target, and by rotating the target by means of an induction motor within the evacuated envelope surrounding the target. The latter solution to the problem of overheating is inapplicable in the field of microfocus X-ray sources, as the magnetic fields associated with the induction motor will distort the electron beam and so make the spot on the target on which the electron beam is incident larger than is required.

According to the present invention there is provided a microfocus X-ray source comprising, a chamber, a target within the chamber, a turbomolecular pump for evacuating the chamber, and means for causing an electron beam to be incident upon a region of the target having a diameter of 15 micrometres or less, wherein the turbomolecular pump has a shaft to which the target is connected so that operation of the pump causes rotation of the target.

Preferably the shaft includes ducts through which, in operation of the source, a cooling medium may be passed to remove heat from the target, and the target is hollow, having a cavity which communicates with the ducts in the shaft.

The invention will now be further described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows a partly broken away view of a microfocus X-ray source; and

Figure 2 shows a side view of the X-ray source of Figure 1.

Referring to Figures 1 and 2, as shown in Figure 1 a microfocus X-ray source 10 comprises a base chamber 12 defined by a cylindrical casing 14 with a flange 16 around the periphery of its upper end, a groove 17 in the flange 16 accommodating an O-ring seal 18. A soft iron bobbin 24 comprising a tube 26 with a wide external flange 28 at its upper end is situated concentrically within the base chamber 12, the flange 28 being supported around its periphery by the flange 16. The bobbin 24 also comprises a concentric hollow tapering boss 30, of the same bore as the tube 26, which extends above the level of the flange 28. At the lower end of the tube 26 is a second flange 32, and focussing coils 34 are wound onto the bobbin 24 between the flange 32 and the flange 28. Around the focussing coils 34 is a soft iron cylindrical tube 36. A ceramic tube 46 of the same bore as the tube 26 extends from the lower end of the tube 26. The end of the ceramic tube 46 remote from the bobbin 24 is sealed, and supports a cathode filament 50 within the ceramic tube 46.

Above the wide flange 28 of the bobbin 24 is a vacuum chamber 60 defined by a tubular casing 62 of the same internal and external diameters as the casing 14 of the base chamber 12. The casing 62 is closed at its upper end and has a flange 64 around its lower end of the same dimensions as the flange 16, and which is supported by the periphery of the flange 28. A groove 66 in the flange 64 accommodates an O-ring seal 18.

A circular hole 80 in one side of the chamber 60 is sealed by a beryllium window 82 transparent to X-rays. In the centre of the vacuum chamber 60 is a solid copper anode 86 of truncated conical form with a tungsten target strip 88 inset into its surface. The axis of the anode 86 is horizontal. The anode 86 is such that if a beam of light were to be shone along the axis of the tube 26, it would hit the target strip 88 and be reflected onto the window 82. The anode 86 is axially mounted to one end of a shaft 90 which extends through a circular hole 92 in the side of the chamber 60 diametrically opposite the side containing the window 82, into a tubular pump casing 94. The shaft 90 is supported centrally in the hole 92 by a high-speed bearing 96 attached to the casing 62 by four equally spaced radially extending legs 98 (only three of which are shown).

The pump casing 94 has at one end a flange 100 attached to a matching annular flat surface 102 on the outside of the casing 62 by screws 104 (only two of which are shown), a vacuum-tight seal being ensured by an O-ring seal 106 in a groove 108 in the surface 98. Within the pump casing 94 the shaft 90 carries a set of several conventional turbomolecular pump blades 110 (twelve of which are shown diagrammatically). The shaft 90 extends through a rotary seal and bearing 120 in the end of the pump casing 94 remote from the vacuum chamber 60, and as shown in Figure 2, is drivably connected to a conventional turbomolecular pump motor 122.

A port 126 through the pump casing 94, more remote from the vacuum chamber 60 than the set of pump blades 110, is connected by a tube 130 to a conventional backing pump 134.

In operation of the microfocus X-ray source 10, the vacuum chamber 60, the tube 26 and the tube 46 are evacuated by the backing pump 134, and then

further evacuated by the set of turbomolecular pump blades 110 by rotating the shaft 90. A potential difference of several thousand volts is applied between the anode 86 and the cathode 50 (the anode 86 being at earth potential for safety) and a current is passed through the cathode filament 50 to raise its temperature. A current is also passed through the focussing coils 34, creating a magnetic field in and around the bobbin 24.

Electrons are emitted by the cathode filament 50 and are attracted towards the anode 86. An electron beam 150 is thus caused to pass down the tube 26, and is focussed by the magnetic field so as to hit a small spot of diameter about 15 micrometres on the target strip 88. As a consequence of the collision of the electrons with the tungsten of the target strip 88, X-rays are created which emerge as a divergent beam 160 through the beryllium window 82, and also heat is generated in the target strip 88.

Owing to the rotation of the anode 86 by the shaft 90, the heat is not concentrated onto a spot of diameter 15 micrometres but rather is spread out along a circumferential line of width 15 micrometres around the conical surface of the target strip 88. The heat is then conducted away through the copper of the anode 86 itself and through the shaft 90.

An alternative microfocus X-ray source (not shown) differs from the source 10 of Figure 1 and 2 in having an anode which is hollow, so as to define a cavity therein, mounted to one end of a shaft comprising two concentric tubes (a central tube and an outer tube) so that the tubes communicate with the cavity. A set of turbomolecular pump blades are attached to the shaft, just as in the source 10, and in all other respects the alternative X-ray source is the same as that of Figures 1 and 2. In operation of the source a cooling liquid is pumped through the cavity, passing along the shaft into the cavity through the central tube, and leaving the cavity through the outer tube. This enables more heat to be removed from the target strip, so enabling a more intense X-ray beam to be created, than in the case of the source 10 of Figures 1 and 2.

Although the target strip 88 has been described as being of tungsten it will be understood that any other high atomic number material, molybdenum, tantalum or gold for example, may be used.

CLAIMS

1. A microfocus X-ray source comprising, a chamber, a target within the chamber, a turbomolecular pump for evacuating the chamber, and means for causing an electron beam to be incident upon a region of the target having a diameter of 15 micrometres or less, wherein the turbomolecular pump has a shaft to which the target is connected so that operation of the pump causes rotation of the target.

2. A source as claimed in Claim 1 wherein the shaft includes ducts through which, in operation of the source, a cooling medium may be passed to remove heat from the target.

3. A source as claimed in Claim 2 wherein the target is hollow, having a cavity which communicates with the ducts in the shaft.

4. A microfocus X-ray source substantially as hereinbefore described and with reference to Figures 1 and 2 of the accompanying drawings.

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